UNITED STATES DEPARTMENT OF AGRICULTURE
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Contribution from the Bureau of Chemistry
CARL L. ALSBERG, Chief

Washington, D. C. April 23, 1920

THE MICROSCOPICAL EXAMINATION OF FLOUR

By

GEORGE L. KEENAN, Microanalyst, and
MARY A. LYONS, Microanalyst, Microchemical Laboratory

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REVIEW OF LITERATURE.

A review of the literature has shown very few methods for the microscopical examination of flours. In the great majority of the methods found, suggestions are offered for the separation of the wheat tissues from the starch material and the subsequent examination of the offal under the microscope. The results obtained from such microscopical examination, however, are only roughly indicative of the offal that may be present.

The work of Delaye (5)[1] was concerned largely with the detection of foreign spores in flour and also with the presence of ergot. Girard (7) suggested the separation of the gluten from the starch and impurities by forming the flour into a cake and washing it with running water. The starch and impurities were separated with a fine sieve, and the offal particles examined under the microscope. Kraemer (11) has offered a quantitative method for the examination of commercial flours by means of the microscope, this quantitative method to be preceded by a general qualitative examination. A small portion of the flour was weighed out, a few drops of a reagent added, and the number of typical starch grains or characteristic tissues enumerated in examining five different portions of the microscopical mount. Standard samples were employed for purposes of com-

[1] The numbers in parenthesis refer to the bibliography on page 32.

parison. As a rule, not less than 12 microscopical mounts were made of the standard and of the sample under examination.

Kohn (10) weighed out one-half gram of the flour, and added 10 cubic centimeters of ether, shaking the mixture, to isolate the hairs and bran tissues which were subsequently identified under the microscope.

Dedrick (4) placed the flour in question upon a glass, and examined it for offal particles, either with the naked eye or by means of a powerful magnifier. Particles of bran, germ, or other impurities or substances differing from flour were enumerated, five and six trials being made and an average struck. In this way he attempted to differentiate between the so-called patent, straight, clear, break, and low-grade flours.

Collin (3) considered the microscopical examination of flour quite extensively, although he did not take up the question from the standpoint of determining the relative amount of offal material present. The histology of the wheat grain is fully discussed and illustrated with a number of figures.

Von Liebermann and Andriska (22) suggested a method for estimating the quality of wheat flour which might possibly be correlated with a microscopical examination. The quality of the flour with respect to the quantity of bran substance present was ascertained by shaking the flour with chloroform, and observing the color of the portion which floated on the surface. The test might be rendered quantitative in the following manner: One gram of the flour was shaken in a tube with 10 cubic centimeters of chloroform, and the mixture allowed to stand for one hour. The depth of color of the layer which then formed on the surface of the chloroform was compared with the colors of the layers produced when mixtures of finest white flours and variable portions of bran were subjected to similar treatment. These mixtures might contain quantities of washed bran ranging from 0 to 2 per cent. The colors of the layers were to be observed from above.

In connection with the work done by Moore and Wilson (15), Patterson has made a microscopical examination of the flour streams from the different machines of the mill, these streams being blended to form various finished flours. Finished flours were also examined. His method consisted in weighing out 3 milligrams (0.003 gram) of flour, dividing this into five portions on as many microscopic slides, wetting with water, covering with cover slips, and then counting under the microscope the number of hairs and epicarp and seed-coat particles in the five slides. His results tended to show how these particles increased in number in streams from the lower-grade machines and were practically absent from those from the "top" of the mill.

PURPOSE OF INVESTIGATION.

From the review of the literature, it is apparent that heretofore the purpose of the microscopical examination of flour has usually been to determine the presence of adulterants, such as other flours, or even starches, spores, etc. The paper in which Patterson indicated the possibilities of an estimation of the offal content of a flour microscopically (15) suggested the work here reported.

MICROSCOPICAL METHOD.

For convenience, the microscopical method employed in this investigation will be described under the following headings: (1) Apparatus, (2) technique, and (3) counting bran particles and hairs.

APPARATUS.

1. Microscopic slide with a ruled area about 22 millimeters square. The lines, which it is convenient to have about ½ millimeter apart, are ruled across the short diameter of the slide.
2. Cover glasses 22 millimeters square.
3. Compound microscope, with compensating ocular 12× and 16 mm. apochromatic objective.
4. Scalpel, preparation needles, camel's-hair brush, spatula, alcohol lamp, mechanical stage.
5. Assay balance.
6. Chloral hydrate solution about 1:1; preferably not any more concentrated.

TECHNIQUE.

Before undertaking the examination of a flour microscopically, the sample should be thoroughly mixed, and a composite sample withdrawn from various parts of the material. A 5-milligram portion of flour is carefully weighed out upon accurate balances, and the weighed portion transferred to the center of the ruled area on the microscopic slide. The scalpel is employed in removing flour from the weighing pan to the slide, the small amount which can not be thus removed being easily brushed onto the slide with the camel's-hair brush. The flour being transferred to the slide, about 3 or 4 drops of chloral hydrate solution are mixed with the flour by means of the preparation needle. Add only enough chloral hydrate solution to fill the space beneath the cover glass. The proper amount is usually about 4 drops when a pipette with a 1-millimeter bore is employed. A pipette of larger bore releases too much solution at a time and is less convenient to control. It is important that the material be evenly distributed in the solution; otherwise flocculation of the flour will occur, rendering counting more difficult and less accurate. The square cover glass is next applied, and the slide heated over the alcohol flame until the

starch grains are dissolved, or the preparation "cleared," as is commonly stated. Vigorous heating of the slide is to be avoided in order to prevent burning of the material before the preparation has been sufficiently cleared. After gentle heating, the slide is quickly transferred to the stage of the microscope, where it is allowed to remain a short time before counting is begun. The cold stage causes the larger part of the air bubbles that may be present in the preparation to disappear, the very few that remain not hindering in the enumeration of the bran particles and hairs.

Careful adherence to the details of this technique is necessary to insure a suitable slide for counting. If a slide is improperly prepared, the resulting count probably will not be representative of the flour under consideration.

COUNTING BRAN PARTICLES AND HAIRS.

A thorough acquaintance with the histology of the wheat grain is essential before attempting an examination of flours. Any standard work on microscopy or plant anatomy of the common food products contains adequate descriptions of the tissues of the wheat berry in various sections. The following brief description of the anatomy of the wheat berry [1] is given for the purpose of indicating the tissues which are depended upon for judging a flour with respect to its offal content.

The wheat grain is, botanically, the fruit of various subspecies and varieties of the genus Triticum. This grain or fruit consists of a series of tissue systems, the outermost of which is the pericarp which is composed of three layers, the epicarp, mesocarp, and endocarp. The pericarp is essentially the fruit coat or matured ovary wall. Within the pericarp is the testa (or spermoderm), rather yellowish-brown in color, and easily distinguished in either cross or surface sections under the microscope. Within the testa is a layer of rectangular cells (in transverse section) known as the aleurone layer, containing protein material but no starch. This is essentially the outer layer of the endosperm or albumen of the seed. The remainder of the grain within the aleurone layer consists of very thin-walled parenchymatous cells packed full of starch grains. The small embryo, or germ, is located at the end opposite the bearded apex. A crease or groove passes longitudinally from the base of the grain to the apex.

The essential purpose of milling is to produce the finely ground endosperm or starchy portion of the wheat grain as free as possible from bran particles, hairs, and germ tissues. These bran particles, hairs, and germ tissues are known as offal in milling terminology. The wheat offal, therefore, consists primarily of all the tissue elements of

[1] A. L. Winton. The Microscopy of Vegetable Foods, 2d ed., pp. 65–73. 1916.

the grain from, and including, the aleurone layer outward, and also the germ tissues. Botanically, the bran consists of the pericarp, or fruit coat, and the aleurone layer.

In order to discover any relation that might exist between the bran particles and hairs and the various so-called grades of flour, the microscopical method already partially described (page 3) was employed to determine the number of bran particles and hairs ordinarily found, in varying amounts, in different classes of flours. This enumeration consisted in methodically examining and recording all of the bran particles and hairs contained in any given slide. It is well to form the habit of always starting at the same point in the mount, as, for example, the lower right-hand corner of the slide. The slide is slowly moved by means of the mechanical stage, and all of the bran particles and hairs detected outside the edge of the cover slip counted. Each particle of spermoderm (with accompanying aleurone layer, if present), epicarp, cross-cell and intermediate-cell tissues, and hairs are given a value of one, no matter how small the particle or hair fragment may be, surface as well as transverse sections being included. After the region outside the cover slip is carefully scrutinized, the slide is moved over the width of the space between the ruled lines, and another strip of the mount examined and the offal[1] counted. A bran particle with hairs attached is counted as so many hairs instead of being recorded, for the sake of convention, with the bran particle count. Germ tissues were not enumerated. This procedure, as described, is methodically followed until the entire slide has been examined.

SOURCES OF VARIATION IN METHOD.

In order to study the reliability of the method aside from its practical application to the examination of flour, a large number of tests were made having for their principal purpose the determination of the probable sources of variation and their extent. In considering this question it was recognized that there might be a variation due to one or all of the following factors: (1) Personal equation, including one analyst's variation in counting the same slide on different days and the variation between two analysts counting the same slide on the same day; (2) daily variation due to the condition of light, etc.; (3) slide variation due to limits of accurate weighing of the test portion of flour; and (4) the variation in homogeneity of the bulk sample.

[1] For the purpose of this investigation bran particles and hairs were considered as constituting the offal.

PERSONAL EQUATION VARIATION.

COUNTING THE SAME SLIDES ON DIFFERENT DAYS BY ONE ANALYST.

Table 1 gives actual data obtained from counts made by each of two analysts working upon three slides which were prepared from the same bulk sample and upon which they made two counts on each of three successive days.

TABLE 1.—*Results of counts of same slides by two analysts on different days.*

Date.	Slide.	Analyst.	Count No.	Bran particles.	Hairs.	Total.
1918.						
Jan. 7	A	Keenan	1	87	59	146
Do.	A	do	2	92	64	156
Do.	B	do	1	60	60	120
Do.	B	do	2	60	58	118
Do.	C	do	1	87	62	149
Do.	C	do	2	81	74	155
Do.	A	Lyons	1	103	58	161
Do.	A	do	2	114	52	166
Do.	B	do	1	86	64	150
Do.	B	do	2	80	58	138
Do.	C	do	1	90	62	152
Do.	C	do	2	87	57	144
Jan. 8	A	Keenan	1	76	66	142
Do.	A	do	2	82	69	151
Do.	B	do	1	60	55	115
Do.	B	do	2	49	48	97
Do.	C	do	1	62	66	128
Do.	C	do	2	64	68	132
Do.	A	Lyons	1	100	54	154
Do.	A	do	2	96	56	152
Do.	B	do	1	85	52	137
Do.	B	do	2	77	55	132
Do.	C	do	1	89	65	154
Do.	C	do	2	83	59	142
Jan. 9	A	Keenan	1	80	65	145
Do.	A	do	2	83	66	149
Do.	B	do	1	49	61	110
Do.	B	do	2	53	57	110
Do.	C	do	1	60	66	126
Do.	C	do	2	77	71	148
Do.	A	Lyons	1	104	54	158
Do.	A	do	2	106	55	161
Do.	B	do	1	78	55	133
Do.	B	do	2	77	55	132
Do.	C	do	1	86	65	151
Do.	C	do	2	86	62	148

For the purpose of emphasizing certain salient points, the results recorded in Table 1 have been rearranged in Table 2, in considering which it is necessary to regard the different portions carefully. Keenan's greatest variation in two counts of bran particles on a given slide on any one day was 17 points (slide C, Jan. 9, 1918), while Lyons' greatest variation was 11 points (slide A, Jan. 7, 1918). In the matter of counting hairs the greatest variation in the counts obtained on a given slide on any one day by Keenan was 12 points (slide C, Jan. 7, 1918), while Lyons' greatest similar variation was 6 (in several instances). In these cases it appears therefore that the personal variation due to the error of counting probably would not exceed 17 points in the case of particles or 12 points in the case of hairs.

TABLE 2.—*Variation in counting of each analyst.*

Slide.	Count No.	Bran particles.			Hairs.		
		Jan. 7, 1918.	Jan. 8, 1918.	Jan. 9, 1918.	Jan. 7, 1918.	Jan. 8, 1918.	Jan. 9, 1918.
	Keenan.						
A	1	87	76	80	59	66	65
A	2	92	82	83	64	69	66
B	1	60	60	49	60	55	61
B	2	60	49	53	58	48	57
C	1	87	62	60	62	66	66
C	2	81	64	77	74	68	71
	Lyons.						
A	1	103	100	104	58	54	54
A	2	114	96	106	52	56	55
B	1	86	85	78	64	52	55
B	2	80	77	77	58	55	55
C	1	90	89	86	62	65	65
C	2	87	83	86	59	62	63

COUNTING THE SAME SLIDE ON THE SAME DAY BY TWO ANALYSTS.

The variation between the counts made by two analysts on the same slide on the same day is demonstrated by comparing the daily averages [1] obtained by each of the two analysts. These data are compiled in Table 3.

TABLE 3.—*Variation in counting of two analysts on same day.*

Date.	Analyst.	Bran particles.			Hairs.		
		Slide A.	Slide B.	Slide C.	Slide A.	Slide B.	Slide C.
1918.							
Jan. 7	Keenan	89	60	84	61	59	63
	Lyons	108	83	88	55	61	59
	Variation	19	23	4	6	2	9
Jan. 8	Keenan	79	54	63	67	51	67
	Lyons	98	81	86	55	53	62
	Variation	19	27	23	12	2	5
Jan. 9	Keenan	81	51	68	65	59	68
	Lyons	105	77	86	54	55	63
	Variation	24	26	18	11	4	5

The table shows an average variation in the count of bran particles of 20, with a range of from 4 to 27. The average variation in the count of hairs was 18, with a range of from 2 to 12. It is evident that the variation between analysts in making the count of bran particles is greater than in making the count on hairs.

DAILY VARIATION DUE TO CONDITION OF LIGHT, ETC.

To determine what influence, if any, physical conditions, such as degree of light, have upon the count, it is necessary to first eliminate, as far as possible, the personal variations already considered. This may be accomplished by taking the average of two counts on three

[1] By "daily average" is meant the average of two counts made by the same analyst on the same slide on a given day.

slides for the same day and averaging the three results to determine the analyst's daily variation. This is calculated for each analyst. The ultimate daily variation is the average of the daily variation of the two analysts computed for each day. The daily variation for each analyst is shown in Table 4.

TABLE 4.—*Daily variation for each analyst.*

Slide.	Variation.	Bran particles.			Hairs.		
		Jan. 7, 1918.	Jan. 8, 1918.	Jan. 9, 1918.	Jan. 7, 1918.	Jan. 8, 1918.	Jan. 9, 1918.
	Keenan.						
A		89	79	81	61	67	65
B		60	54	51	59	51	59
C		84	63	68	68	67	68
	Analyst's daily	77	65	66	62	61	64
	Lyons.						
A		108	98	105	55	55	54
B		83	81	77	61	53	55
C		88	86	86	59	62	63
	Analyst's daily	93	88	86	58	56	57
	Ultimate daily	85	76	76	60	63	60

The results in Table 4 seem to indicate that on January 7, 1918, there was a tendency to count higher on bran particles than on the other days. It is believed, however, that this was in whole or in part due to the clearing action of the glycerin employed to preserve the slides for counting on subsequent days, which tended to make the identification of the bran particles more difficult after the first day.

SLIDE VARIATION DUE TO LIMITS OF ACCURATE WEIGHING OF THE TEST PORTION OF FLOUR.

In order to determine the absolute variation between the slides, it is evident that an average must be obtained from which the personal variations and the daily variations have been eliminated as far as possible. This is accomplished by computing for each slide the average of all counts made on bran particles, and also making a similar computation for the hair count (Table 5).

TABLE 5.—*Counts of bran particles and hairs on slides.*

Bran particles.			Hairs.		
Slide A.	Slide B.	Slide C.	Slide A.	Slide B.	Slide C.
89	60	84	61	59	68
79	54	63	67	51	67
81	51	68	65	59	68
108	83	88	55	61	59
98	81	86	55	53	62
105	77	86	54	55	63
[1] 93	[1] 67	[1] 79	[1] 59	[1] 56	[1] 64

[1] Average slide count.

The variation in the counts on these slides naturally raises the question of the limits of accuracy in weighing out the test portion of flour. Since the amount of flour used on a slide is 5 milligrams, it is desirable to determine how great is the error due to weighing the test portion of flour. The balance employed in this investigation was a fine assay balance. In weighing the sample the vibration method was used, and the quantity of flour was so adjusted as to produce a deviation of approximately not more than one-fourth of a space on each side of the zero point of the scale. This is equivalent to not more than 1/40 milligram, or one-half of 1 per cent, on the basis of the portion of flour used (5 milligrams). Hence any error in weighing can not be accepted as an explanation of the difference in slide counts.

VARIATION IN HOMOGENEITY OF BULK SAMPLE.

The question has been raised as to whether or not a portion of the slide variation might not be accredited to lack of uniformity of the bulk sample, due to the fact that any grade of flour is usually the component result of several constituent streams which vary more or less among themselves. The fact that in general practice the flour stocks are subjected to a certain degree of purification, however, leaves this factor little chance to figure to any great extent. This point was tested by passing a certain sample of flour which had an average count of 32 bran particles and 64 hairs through a 30-mesh sieve and making up and counting 12 slides. The bulk sample was then passed through the sieve once more (making two times for the sample), and another series of slides made and counted. Finally, the sample was put through the sieve twice more (making four times for the sample), and a third series of 12 slides made and counted. The results of these tests are given in Table 6, the counts in which are the average of the results obtained by two persons.

TABLE 6.—*Effect of variation in homogeneity of sample on count.*

Sample passed through 30-mesh sieve—					
Once.		Twice.		Four times.	
Bran particles.	Hairs.	Bran particles.	Hairs.	Bran particles.	Hairs.
31	73	26	67	21	76
48	73	37	70	22	53
36	58	25	58	30	56
33	53	22	54	32	81
41	64	27	61	23	79
36	64	32	57	29	66
35	74	32	83	36	60
35	75	27	64	34	56
37	57	34	61	39	70
35	76	26	72	38	52
30	66	39	67	33	65
34	60	30	67	37	48
[1] 35	[1] 66	[1] 29	[1] 65	[1] 31	[1] 63
[2] 18	[2] 23	[2] 17	[2] 29	[2] 18	[2] 31

[1] Average. [2] Variation

Apparently, sifting or thorough mixing of the flour a number of times has little appreciable effect upon the offal count obtained.

NUMBER OF SLIDES COUNTED.

In practice, two slides, or at most three, from the sample of flour have been used as the basis for judgment as to the character of the product as far as the offal material was concerned, and the question might very properly be asked if that number is sufficient. In order to test out this point, 12 slides were prepared from the same bulk sample of flour. Two counts on each slide were made of the bran particles and hairs by each of two analysts. The results obtained are recorded in Table 7.

TABLE 7.—*Counts on 12 slides.*

Slide designation.	Analyst.	Count No.	Bran particles.	Hairs.	Slide designation.	Analyst.	Count No.	Bran particles.	Hairs.
A	Keenan	1	21	76	G	Keenan	1	38	64
A	do	2	22	75	G	do	2	32	57
A	Lyons	1	20	78	G	Lyons	1	35	61
A	do	2	22	77	G	do	2	40	61
B	Keenan	1	24	54	H	Keenan	1	37	61
B	do	2	23	53	H	do	2	24	47
B	Lyons	1	19	52	H	Lyons	1	38	56
B	do	2	23	56	H	do	2	40	61
C	Keenan	1	23	55	I	Keenan	1	26	74
C	do	2	31	60	I	do	2	44	67
C	Lyons	1	34	59	I	Lyons	1	44	67
C	do	2	33	53	I	do	2	42	72
D	Keenan	1	33	77	J	Keenan	1	39	50
D	do	2	30	81	J	do	2	38	55
D	Lyons	1	31	84	J	Lyons	1	34	48
D	do	2	35	82	J	do	2	41	56
E	Keenan	1	24	79	K	Keenan	1	32	63
E	do	2	22	79	K	do	2	30	60
E	Lyons	1	23	82	K	Lyons	1	33	68
E	do	2	26	78	K	do	2	37	71
F	Keenan	1	31	64	L	Keenan	1	32	47
F	do	2	29	65	L	do	2	36	49
F	Lyons	1	29	70	L	Lyons	1	42	47
F	do	2	30	66	L	do	2	39	51

From the data in Table 7 it is possible to average Keenan's first count on slide A with each count made by him on each of the other slides. By averaging the slides by two, 20 is found to be the lowest average and 43 the highest average for bran particles, considering Keenan's results only. If the average of counts for three slides instead of two is to be taken as the basis for final judgment of the product, it is apparent that 22 is the average of the three lowest results and 40 the average of the three highest (Keenan's results on bran particles). Taking the average of the counts on each of four slides gives an average minimum count of 22 and an average maximum count of 39. Table 8, based on data obtained from Table 7, has been prepared to show the results of such methods of grouping.

TABLE 8.—*Effect of method of computing average on count.*

Method of averaging.	Bran particles.				Hairs.			
	Keenan.		Lyons.		Keenan.		Lyons.	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
By twos	20	43	19	43	48	80	49	83
By threes	22	40	20	42	47	79	48	81
By fours	22	39	21	41	49	79	49	81
By fives	23	39	21	41	51	77	50	80

EXAMINATION OF MILL STOCKS.[1]

Before undertaking a discussion of the work done on finished commercial flours, it seemed advisable to consider the degree of purity of the various mill stocks entering into the composition of the end-product. The data compiled in Table 9 demonstrate the quality of the stocks made on the break rolls, the purpose of which is to crush the wheat kernel to release the enclosed endosperm that is later reduced to fineness on other rolls and finally purified of offal débris. The general practice in milling is to make as little break flour as possible. When break flour is made to any extent, it invariably contains a notable amount of offal, consisting of bran particles, as well as numerous hairs from the beard. The results recorded in Table 9 were obtained on samples of material procured from the first, second, third, and fourth break rolls, respectively, and from different mills. It was stated that they had been bolted through silks of various numbers of meshes per lineal inch, the following silks being employed:

Silk number.	Meshes per inch.
10xx	109
11xx	116
12xx	125
12x	125
12xxx	125
13xx	129
14xxx	139

[1] The designations for the various stocks and grades of flour examined, as well as the statements concerning the kind of wheat from which the flour was milled, were taken from the millers supplying the samples and were not verified in the Bureau of Chemistry.

TABLE 9.—*Results of examination of products from break machines.*

Sample No.	Type of wheat.	Bolting cloth.	Bran particles.	Hairs.	Total.
		FIRST BREAK MATERIAL.			
11079-K-A	Hard	(?)	196	165	361
17146-L-B	do	11xx, 13xx	186	83	269
17125-L-C	Hard and soft	(?)	117	43	160
17128-L-A	do	(?)	334	162	496
17159-L-A	do	(?)	76	61	137
17173-L-A	do	(?)	46	64	110
17165-L-O	Soft	10xx	113	38	151
17167-L-A	do	12xxx, 14xxx	182	58	240
		SECOND BREAK MATERIAL.			
17143-L-B	Hard	10x, 11x	324	42	366
17146-L-A	do	12xx, 13xx	166	65	231
17190-L-B	do	12xx, 13xx	216	162	378
17125-L-D	Hard and soft	(?)	105	23	128
17128-L-C	do	(?)	150	83	233
17159-L-B	do	(?)	47	44	91
17173-L-B	do	(?)	32	54	86
17133-L-F	Soft	(?)	142	58	200
17165-L-P	do	10xx	75	38	113
17167-L-B	do	12xxx, 14xxx	138	31	169
		THIRD BREAK MATERIAL.			
11079-K-D	Hard	(?)	120	121	241
17143-L-C	do	10x, 11x	628	107	735
17146-L-D	do	12xx, 13xx	367	144	511
17125-L-E	Hard and soft	(?)	159	26	185
17128-L-D	do	(?)	118	53	171
17159-L-C	do	(?)	68	60	128
17173-L-C	do	(?)	37	56	93
17133-L-G	Soft	(?)	375	73	448
17165-L-Q	do	10xx	131	53	184
17167-L-C	do	12xxx, 14xxx	135	46	181
		FOURTH BREAK MATERIAL.			
17143-L-D	Hard	11x, 12x	810	213	1,023
17146-L-C	do	12xx, 13xx	322	116	438
17125-L-F	Hard and soft	(?)	262	57	319
17128-L-E	do	(?)	118	50	168
17173-L-D	do	(?)	132	147	279
17165-L-R	Soft	10xx	228	106	334
17167-L-D	do	14xxx	285	66	351

For the purpose of comparison, the data from Table 9 have been summarized in Table 10.

TABLE 10.—*Summary of results of examination of products from break machines.*

Machine stock.	Average.	
	Bran particles.	Hairs.
First break	156	84
Second break	139	60
Third break	213	73
Fourth break	308	122

The offal content of the break roll products is high, as would be expected. A microscopical examination is hardly necessary to establish this fact. The fluffy and dirty appearance of such products, even from casual examination, is sufficient to show that they are of low quality, judging from the offal material present.

Tests similar to those made on break roll products were made on middlings stock. Middlings are usually recognized as being the medium granular particles of the endosperm resulting from the cracking of the wheat kernel on the break rolls. After proper purification or removal of the branny material, the middlings are milled, on the reduction rolls, to the fineness of flour. The results of experimental work done on middlings stocks are recorded in Table 11.

TABLE 11.—*Results of examination of middlings stocks.*

Sample No.	Type of wheat.	Bolting cloth.	Bran particles.	Hairs.	Total.
		FIRST MIDDLINGS STOCK.			
15196-K-E	Hard	10xx, 11xx, 12xx	22	18	40
17144-L-I	do	10x	14	4	18
17190-L-I	do	10xx	36	16	52
17125-L-L	Hard and soft	(?)	23	2	25
17159-L-F	do	(?)	18	22	40
17132-L-J	Soft	(?)	19	3	22
17133-L-L	do	(?)	59	12	71
17165-L-B	do	10xx	21	8	29
17185-L-C	do	10xx	5	2	7
		SECOND MIDDLINGS STOCK.			
15196-K-C	Hard	12xx, 13xx, 14xx	5	3	8
17144-L-J	do	10x	7	3	10
17146-L-G	do	11xx, 12xx	29	2	31
17190-L-I	do	11xx	100	50	150
17125-L-N	Hard and soft	(?)	11	1	12
17159-L-G	do	(?)	7	5	12
17132-L-K	Soft	(?)	25	1	26
17133-L-O	do	(?)	59	6	65
17165-L-C	do	10xx	48	27	75
17185-L-D	do	10xx	8	4	12
		THIRD MIDDLINGS STOCK.			
17144-L-K	Hard	10x, 11x	8	1	9
17146-L-I	do	11x, 12xx	27	6	33
17190-L-J	do	10xx, 11xx	14	5	19
17125-L-P	Hard and soft	(?)	6	3	9
17128-L-K	do	(?)	69	26	95
17159-L-H	do	(?)	19	22	41
17173-L-O	do	(?)	18	24	42
17132-L-L	Soft	(?)	9	0	9
17133-L-Q	do	(?)	34	5	39
17165-L-D	do	10xx	36	7	33
17167-L-J	do	14xxx	21	5	26
17185-L-F	do	10xx	9	4	13
		FOURTH MIDDLINGS STOCK.			
15196-K-J	Hard	11xx, 12xx, 14xx	10	6	16
17190-L-K	do	11xx, 12xx	76	25	101
17125-L-T	Hard and soft	(?)	7	1	8
17128-L-O	do	(?)	38	23	61
17159-L-I	do	(?)	8	10	18
17171-L-L	do	11xxx, 12xx	82	9	91
17132-L-M	Soft	(?)	26	1	27
17133-L-S	do	(?)	26	5	31
17165-L-F	do	12xx	29	2	31
17167-L-M	do	(?)	115	24	139
17167-L-K	do	(?)	40	6	46
		FIFTH MIDDLINGS STOCK.			
15196-K-K	Hard	11xx, 12xx, 14xx	18	13	31
17144-L-M	do	10x, 11x	9	1	10
17146-L-H	do	11xx, 12xx	21	5	26
17190-L-L	do	11xx, 12xx	74	22	96
17128-L-P	Hard and soft	(?)	74	36	110
17159-L-J	do	(?)	10	9	19
17171-L-M	do	12xx	65	19	84
17173-L-P	do	(?)	57	57	114
17133-L-U	Soft	(?)	80	18	98
17165-L-H	do	12xx	55	12	67
17167-L-O	do	(?)	43	10	53

TABLE 11.—*Results of examination of middlings stocks*—Continued.

Sample No.	Type of wheat.	Bolting cloth.	Bran particles.	Hairs.	Total.
		SIXTH MIDDLINGS STOCK.			
15196-K-G	Hard	11xx, 12xx, 13xx, 14xx	26	30	56
17144-L-N	do	11x, 12x, 13xx	24	1	25
17190-L-M	do	11xx, 12xx	139	33	172
17125-L-BB	Hard and soft	(?)	87	15	102
17128-L-Q	do	(?)	70	37	107
17173-L-Q	do	(?)	41	66	107
17173-L-R	do	(?)	22	35	57
17133-L-W	Soft	(?)	140	18	158
17165-L-I	do	12xx	60	18	78
		SEVENTH MIDDLINGS STOCK.			
15196-K-F	Hard	12xx, 13xx, 14xx	16	9	25
17144-L-O	do	12x, 13x	36	4	40
17190-L-N	do	13xx, 14xx	119	43	162
17128-L-R	Hard and soft	(?)	63	26	89
17159-L-M	do	(?)	104	78	182
17133-L-X	Soft	(?)	194	16	210
17165-L-J	do	12xx, 13xx	143	23	166
17167-L-L	do	(?)	45	13	58
		EIGHTH MIDDLINGS STOCK.			
17190-L-O	Hard	13xx, 14xx	137	23	160
17173-L-S	Hard and soft	(?)	51	52	103
17165-L-K	Soft	13xx, 14xx	264	38	302
		NINTH MIDDLINGS STOCK.			
17167-L-S	Soft	(?)	92	25	117

The average results obtained on the middlings stocks examined have been summarized in Table 12.

TABLE 12.—*Summary of results of examination of middlings stocks.*

Stock.	Average.		Total.
	Bran particles.	Hairs.	
First middlings	24	9	33
Second middlings	29	10	39
Third middlings	21	9	30
Fourth middlings	41	10	51
Fifth middlings	46	18	64
Sixth middlings	65	26	91
Seventh middlings	90	26	116
Eighth middlings	150	37	187
Ninth middlings	92	25	117

The results in Table 12 clearly demonstrate that the middlings stocks are much cleaner than stocks obtained from the break rolls. The first five middlings stocks average low in the total offal count, while the stocks from the sixth to ninth middlings, inclusive, average appreciably higher. In other words, the more thorough the purification process, the lower will be the offal count.

For the purpose of showing the offal count on the stocks which pass into some so-called patent flours, three different sets of mill streams

were examined, these streams being designated as entering into the composition of certain finished flours. The mill streams composing such flours were milled from hard, blended, and soft wheats, respectively. The results of these examinations are shown in Tables 13, 14, and 15.

TABLE 13.—*Results of examination of mill streams composing a patent flour (sample No. 17144–L–FF) milled from hard wheat.*

Stock.	Bran particles.	Hairs.	Total.
First middlings	14	4	18
Second middlings	7	3	10
Third middlings	8	1	9
Fourth middlings	19	2	21
Fifth middlings	9	1	10
Sixth middlings	24	1	25
Seventh middlings	36	4	40
Middlings	36	5	41
Do	30	5	35
First sizings	59	8	67
Second sizings	37	2	39
Sizings	151	20	171
Finished flour (70 per cent patent)[1]	13	2	15

[1] This finished flour is composed of the stocks described above it.

TABLE 14.—*Results of examination of mill streams composing a patent flour (sample No. 17159–L–V) milled from blended wheat.*

Stock.	Bran particles.	Hairs.	Total.
First break	76	61	137
Second break	47	44	91
Third break	68	60	128
Break chops	41	54	95
Do	56	84	140
First middlings	18	22	40
Second middlings	7	5	12
Third middlings	19	22	41
Fourth middlings	8	10	18
Fifth middlings (head)	10	9	19
Fifth middlings (tail)	19	14	33
Coarse tailings	19	13	32
Coarse sizings	6	8	14
Finished flour (70 per cent patent)[1]	20	15	35

[1] This finished flour is composed of the stocks described above it.

TABLE 15.—*Results of examination of mill streams composing a patent flour (sample No. 17132–L–U) milled from soft wheat.*

Stock.	Bran particles.	Hairs.	Total.
First middlings	19	3	22
Second middlings	25	1	26
Third middlings	9	0	9
Fourth middlings	26	1	27
Fine sizings	10	1	11
Medium sizings	21	2	23
Coarse sizings	14	2	16
Finished flour (60 per cent patent)[1]	19	1	20

[1] This finished flour is composed of the stocks described above it.

It is interesting to observe the variety of streams drawn upon for the composition of different so-called patents, as well as the variation in the offal count of the stocks employed in the milling of such finished flours. If space permitted, additional information could be submitted to illustrate how variable the different mill stocks are as far as offal content is concerned. In many instances where lower-grade stocks have been employed in making a flour, however, the finished product has usually been purified sufficiently to cause the resultant offal count to be appreciably low. And in many cases the contrary is true.

EXAMINATION OF COMMERCIAL GRADES OF FLOUR.

The assembled flours employed in this part of the investigation were collected by B. C. Winslow, food and drug inspector, Bureau of Chemistry, United States Department of Agriculture. As these flours were milled under a variety of conditions, they necessarily reflect such conditions in the finished product. The inspector gave the following statement as to the designations applied to these flours: "As a general thing, these names were used in harmony with the usage of the mill where they were taken. The method of assembling, with the streams, percentages, etc., were given when feasible, and as correctly as possible from the information available. The general terms 'patent,' 'clear,' and 'straight' were used to classify in a general way the assembled grades of flour, and vary with each mill."

With this information in mind, an attempt was made to apply the microscopical method already described to an examination of these products for the purpose of developing a system for the classification of flours based on the offal content. A detailed discussion of the actual data obtained from these tests, with a general summary on the various so-called grades, follows.

PATENT FLOURS.

PATENT FLOURS MILLED FROM HARD WHEATS.

Thirty-six patent flours said to have been milled from hard wheats were examined microscopically, and their bran particle and hair count determined. The commercial grade designations ranged from 40 to 94 per cent. In some instances the flour had been bleached; in others it was bleached only lightly or not at all. Table 16 gives the results of this examination.

TABLE 16.—*Results of examination of patent flours milled from hard wheats.*

Sample No.	Commercial grade.	Bleached.	Bran particles.	Hairs.	Total.
	"Per cent patent."				
15163-K-R	(?)	Yes	16	8	24
15178-K-U	(?)	(?)	29	13	42
17151-L-MM	40	No	19	13	32
17151-L-NN	52	No	72	45	117
17150-L-T	58½	No	27	9	36
15152-K-A	60	Yes	15	5	20
15134-K-EE	65	No	24	20	44
11078-K-LL	68	No	23	20	43
11078-K-MM	68	Yes	22	15	37
11070-K-FF	70	(?)	22	21	43
15112-K	70	No	16	12	28
15113-K	70	Lightly	17	11	28
17154-L-AA	71	No	20	10	30
15174-K-LL	72	(?)	17	4	21
15187-K-X	72	No	27	14	41
15170-K-CC	74	No	29	26	55
17144-L-FF	74	No	13	2	15
17190-L-CC	75	Yes	66	33	99
17143-L-CC	75	No	33	2	35
15193-K-EE	75	No	33	36	69
15193-K-DD	75	Yes	30	39	69
11028-K-B	75	(?)	19	13	32
17157-L-A	77	Yes	25	24	49
17183-L-A	78	No	35	28	63
17184-L-Q	79	Yes	25	31	56
11064-K-A	80	No	54	28	82
17175-L-MM	80	No	44	9	53
15181-K-S	80	No	17	19	36
17147-L-BB	83	Yes	34	16	50
17148-L-MM	83	Yes	34	10	44
17156-L-FF	83	Yes	36	30	66
17155-L-JJ	84	No	33	12	45
55135-K-CC	85	No	32	23	55
17145-L-B	85	No	36	15	51
17111-L-S	88	No	33	9	42
17180-L-JJ	94	Yes	62	34	96

On these hard-wheat patents the bran particle count ranged from 15 to 72, with an average of 30. The hair count ranged from 2 to 45, with an average of 18. The total offal count ranged from 15 to 117, with an average of 45.

PATENT FLOURS MILLED FROM SOFT WHEATS.

The patent flours milled from soft wheats are more starchy than those milled from hard wheats. This starchy character is manifest even when the sample of flour is poured out upon a piece of paper. The soft-wheat flour will not "flow" like a flour made from hard wheat, but is more "powdery" and starchlike rather than granular, as in the case of hard-wheat flours. Thirteen patent flours stated to have been milled from soft wheats were examined microscopically. As in the case of hard-wheat flours, the commercial grades, as indicated by percentages, varied markedly, and can be regarded only as approximate. The percentages ranged from 35 to 90 per cent. Some of the flours were bleached, others lightly bleached, and still others not bleached at all. Table 17 gives the results of this examination.

TABLE 17.—*Results of examination of patent flours milled from soft wheats.*

Sample No.	Commercial grade.	Bleached.	Bran particles.	Hairs.	Total.
	"Per cent patent."				
17161-L-A	(?)	Yes	72	10	82
17189-L-O	35	No	32	25	57
17167-L-FF	40	Yes	32	11	43
17165-L-EE	45	Yes	33	32	65
17132-L-U	60	No	19	1	20
17169-L-S	60	(?)	49	34	83
17187-L-V	60	No	23	17	40
15121-K-EE	65	Yes	50	12	62
15126-K-FFF	65	Yes	56	22	78
17133-L-FF	65	Yes	133	29	162
17161-L-LLL	67	No	46	19	65
17164-L-T	75–80	(?)	53	26	79
11007-K	90	(?)	51	30	81

The bran particle count varied from 19 to 133, the hair count from 1 to 34, and the total offal count from 20 to 162. The average count for bran particles was 49 and that for hairs 20, while the average total offal count amounted to 70.

PATENT FLOURS MILLED FROM BLENDED WHEATS.

The flours classified under blends were manufactured from mixtures of hard and soft wheats. Similar information was obtained for these flours as for the hard and soft types. The designations for the so-called grades varied from 70 to 85 per cent. Of the 12 samples examined, 4 were bleached and 8 unbleached. Table 18 gives the results.

TABLE 18.—*Results of examination of patent flours milled from blended wheats.*

Sample No.	Commercial grade.	Bleached.	Bran particles.	Hairs.	Total.
	"Per cent patent."				
11084-K	70	No	29	13	42
11085-K	70	Lightly	32	13	45
11086-K	70	Heavily	31	18	49
17159-L-V	70	No	20	15	35
17171-L-B	70	No	51	25	76
17168-L-YS	75	No	40	37	77
17168-L-YYH	75	No	18	13	31
17179-L-YY	80	No	36	19	55
17127-L-S	82	No	63	27	90
17116-L-D	83	Yes	61	40	101
17123-L-FF	85	Yes	47	21	68
17125-L-FF	85	No	83	17	100

The bran particle count ranged from 18 to 83, with an average of 42. The hair count ranged from 13 to 40, with an average of 21. The total offal count ranged from 31 to 101, with an average of 64.

PATENT FLOURS MILLED FROM MIDDLINGS STOCKS ONLY.

Information was obtained concerning the history of the mill streams entering into the composition of a large number of so-called patent flours. The data collected showed that middlings stocks only were employed in composing these flours. The results of the counts made on these samples are recorded in Table 19.

TABLE 19.—*Results of examination of patent flours milled from middlings stocks only.*

Sample No.	Commercial grade.	Bleached.	Bran particles.	Hairs.	Total.
	"Per cent patent."				
17151-L-MM	40	(?)	19	13	32
15152-K-A	60	Yes	15	5	20
11070-K-FF	70	(?)	22	21	43
17154-L-AA	71	No	20	10	30
17158-L-X	71	Yes	19	13	32
15186-K-X	72	No	27	14	41
15174-K-LL	72	(?)	17	4	21
15170-K-CC	74	No	29	26	55
17144-L-FF	74	No	13	2	15
15181-K-S	80	Yes	17	19	36
15146-K-W	Short patent.	(?)	28	23	51
15163-K-R	(?)	Yes	16	8	24

Table 19 shows that the bran particle count ranged from 13 to 29, with an average of 20, that the hair count ranged from 2 to 26, with an average of 13, and that the total offal count ranged from 15 to 55, with an average of 33. These results demonstrate the fact that the purified middlings stocks employed had some effect upon the purity of the end-product. From the information the writers were able to obtain, however, so-called patent flours were not always composed of the best streams in the mill.

PATENT FLOURS MILLED FROM MIDDLINGS STOCKS PLUS LOWER-GRADE STOCKS IN THE MILL.

As already stated, stocks other than first-class middlings were often passed into patent flours. According to the information submitted, break flours and lower grades of middlings frequently were found to have been employed in the manufacture of the finished flour. The results recorded in Table 20 illustrate the effect of the addition of mill streams appreciably high in offal to the finished product.

TABLE 20.—*Results of examination of patent flours milled from middlings stocks in addition to lower-grade stocks in the mill.*

Sample No.	Commercial grade.	Variety of wheat.	Bleached.	Bran particles.	Hairs.	Total.
	Per cent.					
17189-L-O	35	Soft	No	32	25	57
17181-L-NN	52	Hard	No	72	45	117
17169-L-S	60	Soft	Yes	49	34	83
17188-L-FF	65	do	Yes	133	29	162
17161-L-LLL	67	do	No	46	19	65
17159-L-V	70	Blend	No	20	15	35
17171-L-B	70	do	No	51	25	76
15183-K-DD	75	Hard	Yes	30	39	69
15193-K-EE	75	do	No	33	36	69
17190-L-CC	75	do	Yes	66	33	99
17178-L-YYH	75	Blend	No	18	13	31
17164-L-T	75–80	Soft	Yes	53	26	79
17183-L-A	78	Hard	No	35	28	63
17184-L-Q	79	do	No	25	31	56
11064-K-A	80	do	No	54	28	82
17179-L-YY	80	Blend	No	36	19	55
17127-L-S	82	do	Yes	63	27	90
17147-L-BB	83	Hard	Yes	34	16	50
17156-L-FF	83	do	Yes	36	30	66
17116-L-D	83	Blend	Yes	61	40	101
17155-L-JJ	84	Hard	No	33	12	45
17128-L-FF	85	Blend	Yes	47	21	68
17125-L-FF	85	do	No	83	17	100
15185-K-CC	85	Hard	No	32	23	55
17180-L-JJ	94	do	Yes	62	34	96

The total offal count on these samples was consistently higher in most cases than the results obtained on samples ground from middlings stock only. The addition of break flour stocks appeared to have a marked effect upon their quality with respect to the offal count. The bran particles ranged in count from 18 to 133, with an average of 48. The hair count ranged from 12 to 45, with an average of 26. The total offal count varied from 31 to 162, with an average of 74.

GENERAL CONCLUSIONS ON PATENT FLOURS.

1. The commercial grades of so-called patent flours ranged from 35 to 90 per cent. These percentage figures apparently were intended to indicate that a certain percentage of the total flour content of the wheat kernel passed into this grade, the remainder being employed in other grades.

2. The average total offal count obtained on all commercial patent flours examined was 57.

3. Patent flours showed a marked variation in the total offal count obtained on different samples from various mills.

4. The limitations and the average counts on bran particles and hairs have been briefly summarized in Table 21.

TABLE 21.—*Limitations and average counts on bran particles and hairs for patent flours.*

Commercial grade.	Bran particles.		Hairs.	
	Variation.	Average.	Variation.	Average.
Hard-wheat patent	13 to 72	30	2 to 45	18
Soft-wheat patent	19 to 133	49	1 to 34	20
Blended-wheat patent	18 to 83	42	13 to 40	21

STRAIGHT FLOURS.

When only one grade of flour is manufactured in the mill, this grade is commercially designated as a straight flour, if it contains the entire flour content of the wheat that it is possible to mill. It might be considered to contain all of the flour that could be obtained from the wheat kernel with the exception of a certain percentage of so-called low-grade or red dog flour. Such a straight flour naturally would contain more of the branny particles from the wheat kernel than would a patent flour. The practice of compositing such a flour apparently varies in different mills. Tests were made upon a large number of straight flours milled from hard, soft, and blended wheats. The detailed information on these tests is given in the following paragraphs.

STRAIGHT FLOURS MILLED FROM HARD WHEATS.

Seventeen straight flours reported as having been milled from hard wheats were examined for their offal content. The commercial grades ranged from 92 to 100 per cent. The results of the examination appear in Table 22.

TABLE 22.—*Results of examination of straight flours milled from hard wheats.*

Sample No.	Commercial grade.	Bleached.	Bran particles.	Hairs.	Total.
	"Per cent straight."				
15196-K-U	92	No	33	34	67
11028-K-E	95	(?)	71	55	126
17157-L-B	95	Yes	50	45	95
17155-L-HH	96	Yes	89	33	122
15154-K-C	97	Yes	37	25	62
15106-K	97½	(?)	57	39	96
11067-K	98	(?)	62	31	93
15136-K-BB	98	Yes	55	51	106
15147-K	98	Yes	58	61	119
15191-K	98	(?)	62	87	149
15194-K-U	98	Yes	71	65	136
17113-L	98	Yes	63	19	82
17152-L-Y	98	(?)	57	26	83
17177-L-XX	98	No	71	47	118
11073-K-GG	100	(?)	76	61	137
17146-L-F	100	No	60	17	77
17186-L-F	100	No	121	22	143

The count obtained on bran particles ranged from 33 to 121 and that on hairs from 17 to 87. The average bran particle count was 64 and the average hair count 43. The total offal count ranged from 62 to 149, with an average of 106.

STRAIGHT FLOURS MILLED FROM SOFT WHEATS.

Seventeen straight flours reported to have been milled from soft wheats were examined. The commercial grades ranged from 90 to 100 per cent. Table 23 gives the results of this examination.

TABLE 23.—*Results of examination of straight flours milled from soft wheats.*

Sample No.	Commercial grade.	Bleached.	Bran particles.	Hairs.	Total.
	"Per cent straight."				
11096-K	90	No	52	40	92
11097-K	90	Lightly	41	31	72
11098-K	90	Heavily	56	38	94
15125-K-BB	90	Yes	92	58	150
15126-K-DDD	90	Yes	89	26	115
17166-L-Q	90	Yes	50	60	110
15125-K-FF	95½	Yes	111	70	181
15125-K-JJ	95½	No	119	54	173
17188-L-X	97	No	55	27	82
15125-K-Y	100	Yes	109	71	180
15125-K-OO	100	Yes	153	81	234
15126-K-AAA	100	Yes	93	40	133
17136-L-Z	100	Yes	97	22	119
17165-L-AA	100	Yes	109	34	143
17176-L-W	100	No	52	39	91
17185-L-H	100	No	34	34	68
17186-L-C	100	No	92	38	130

The bran particle count varied from 34 to 153, with an average of 82, and the hair count varied from 22 to 81, with an average of 45. The total offal count ranged from 68 to 234, with an average of 127.

STRAIGHT FLOURS MILLED FROM BLENDED WHEATS.

Eighteen samples of flour stated to have been milled from blends of hard and soft wheats were examined for their offal content, as in the case of the hard and soft types. The commercial grade designations varied from 90 to 100 per cent. The results of the examination are given in Table 24.

TABLE 24.—*Results of examination of straight flours milled from blended wheats.*

Sample No.	Commercial grade.	Bleached.	Bran particles.	Hairs.	Total.
	"Per cent straight."				
11087-K	90	No	50	26	76
11088-K	90	Lightly	51	22	73
11089-K	90	Heavily	50	28	78
17118-L-J	90	No	183	18	201
17173-L-V	90	Yes	21	36	57
11096-K	90	No	52	40	92
11097-K	90	Lightly	41	31	72
11098-K	90	Heavily	56	38	94
17120-L-N	96	Yes	90	47	137
17121-L-SS	97	No	98	30	128
11090-K	97½	No	42	28	70
11091-K	97½	Lightly	43	29	72
11092-K	97½	Heavily	52	26	78
17117-L-DD	97½	Yes	73	37	110
17115-L-E	96½	No	83	45	128
17173-L-W	98	No	33	47	80
15195-K-A	100	No	88	58	146
17128-L-Z	(?)	No	86	37	123

The bran particle count varied from 33 to 183, with an average of 68, while the hair count varied from 18 to 58, with an average of 34. The total offal count varied from 57 to 201, with an average of 100. The average total offal count obtained for the straight flours was 111, as against 57 for patent flours.

MILL STREAMS EMPLOYED IN THE MANUFACTURE OF CERTAIN STRAIGHT FLOURS.

Data were obtained on the mill streams employed in the manufacture of certain straight flours, and these streams were examined for their offal content for the purpose of illustrating the quality of the material sometimes used in making up such flours. The results are given in Tables 25, 26, and 27.

TABLE 25.—*Results of examination of mill streams employed in the manufacture of a straight flour (sample No. 17146–L–F) milled from hard wheats.*

Stock.	Bran particles.	Hairs.	Total.
First break	186	83	269
Second break	166	65	231
Third break	367	144	511
Fourth break	322	116	438
Fifth break	456	176	632
Second middlings	29	2	31
Third middlings	27	6	33
Third middlings (second stream)	13	4	17
Fifth middlings	21	5	26
Cut-off flour	15	4	19
Cut-off flour	76	18	94
Chunk flour	308	90	398
Second chunk flour	50	5	55
Tailings flour	76	24	100
Tailings flour	155	47	202
100 per cent straight flour [1]	60	17	77

[1] Composited from the mill streams listed above it.

TABLE 26.—*Results of examination of mill streams employed in the manufacture of a straight flour (sample No. 17165–L–AA) milled from soft wheats.*

Stock.	Bran particles.	Hairs.	Total.
First break	113	38	151
Second break	75	38	113
Third break	131	53	184
First, second, and third breaks	101	45	146
Fourth break	228	106	334
Fifth break	368	173	541
First middlings	21	8	29
Second middlings	48	27	75
Third middlings	26	7	33
Fourth middlings	29	2	31
Fifth middlings	55	12	67
Sixth middlings	60	18	78
Seventh middlings	143	23	166
Eighth middlings	264	38	302
First germ flour	50	5	55
100 per cent straight flour [1]	109	34	143

[1] Composited from the mill streams listed above it.

TABLE 27.—*Results of examination of mill streams employed in the manufacture of a straight flour (sample No. 17128–L–Z) milled from blended wheats.*

Stock.	Bran particles.	Hairs.	Total.
First break	334	162	496
Second break	150	83	233
Third break	118	53	171
Fourth break	118	50	168
Fifth break	296	101	397
First middlings	66	31	97
Second middlings	41	21	62
Third middlings	69	26	95
Fourth middlings	38	23	61
Fifth middlings	74	36	110
Sixth middlings	70	37	107
Seventh middlings	63	26	89
First sizings	56	11	67
Second sizings	107	34	141
First tailings	134	43	177
Second tailings	108	48	156
Head cuts	132	63	195
Tail cuts	130	70	200
Straight flour[1]	87	37	124

[1] Composited from the mill streams listed above it.

GENERAL CONCLUSIONS ON STRAIGHT FLOURS.

1. The commercial grades of so-called straight flours ranged from 90 to 100 per cent.

2. The average total offal count obtained on all commercial straight flours examined was 111.

3. Straight flours showed a decided variation in the total offal count obtained on different samples from various mills.

CLEAR FLOURS.

Clear flour, so-called, is often considered among millers as being a mixture of odds and ends of the milling stocks. Low grades of middlings and break flours often pass into it, although frequently it contains the purest quality of middlings stock from the tail of the mill. Clear flours which were said to have been milled from hard, soft, and blended wheats, respectively, were examined.

CLEAR FLOURS MILLED FROM HARD WHEATS.

Thirty-one clear flours stated to have been milled from hard wheats were examined. Their percentages ranged from 6 to 52. Table 28 shows the counts thus obtained.

TABLE 28.—*Results of examination of clear flours milled from hard wheats.*

Sample No.	Commercial grade.	Bleached.	Bran particles.	Hairs.	Total.
	"Per cent clear."				
17180-L-KK	6	Yes	331	132	463
17151-L-OO	8	No	238	166	404
17142-L-EE	10	No	306	50	356
17112-L-T	12	No	191	98	289
17150-L-U	12	No	197	77	274
15138-K-DD	13	No	156	126	282
17154-L-CC	14	No	294	223	517
17145-L-A	15	No	181	102	283
17147-L-AA	15	No	271	184	455
17175-L-NN	15	No	241	62	303
17183-L-B	16	No	193	136	329
17184-L-P	16	No	127	119	246
11065-K-A	18	(?)	65	39	104
11079-K-JJ	22	No	82	68	150
11079-K-KK	22	Yes	71	67	138
15169-K-DD	23	(?)	131	124	255
15192-K-FF	23	Yes	410	196	606
15186-K-Y	24	No	172	140	312
11028-K-C	25	(?)	193	204	397
15175-K-MM	25	(?)	158	102	260
17143-L-BB	25	No	316	71	387
17144-L-II	26	No	271	93	364
15115-K	27½	No	92	71	163
15116-K	27½	Lightly	79	57	136
15117-K	27½	Heavily	77	49	126
11071-K-EE	30	(?)	127	178	305
17186-L-E	30	No	268	43	311
15150-K-AA	35	Yes	118	133	251
15137-K-FF	33–35	(?)	126	114	240
15180-K-AA	18	(?)	151	147	298
17151-L-NN	52	No	72	45	117

The bran particle count on these samples varied from 65 to 331, with an average of 174. The hair count ranged from 43 to 223, with an average of 109. The total offal count varied from 104 to 517, with an average of 295.

CLEAR FLOURS MILLED FROM SOFT WHEATS.

Thirteen samples of clear flour reported to have been milled from soft wheats were examined, these samples varying from 5½ to 50 per cent as far as commercial grades are concerned. Table 29 gives the results obtained.

TABLE 29.—*Results of examination of clear flours milled from soft wheats.*

Sample No.	Commercial grade.	Bleached.	Bran particles.	Hairs.	Total.
	"Per cent clear."				
15122-K-AA	5½	Yes	243	155	398
15122-K-LL	5½	No	244	164	408
15126-K-EEE	5½	(?)	282	99	381
17178-L-AAS	20	No	137	66	203
17132-L-W	25	No	308	30	338
15122-K-DD	30	Yes	245	167	412
15122-K-MM	30	No	208	143	351
17160-L-D	30	Yes	235	44	279
17162-L-U	30	No	160	40	200
17133-L-EE	35	Yes	247	39	286
17167-L-GG	50	Yes	126	32	158
17186-L-B	50	No	177	68	245
11006-K	25	(?)	253	72	325

The bran particle count varied from 126 to 308, with an average of 218. The hair count ranged from 30 to 167, with an average of 86. The total offal count ranged from 158 to 412, with an average of 306.

CLEAR FLOURS MILLED FROM BLENDED WHEATS.

Twelve samples of flour stated to have been milled from blended wheats were examined. The commercial grades ranged from 10 to 30 per cent. Table 30 gives the results of the examination.

TABLE 30.—*Results of examination of clear flours milled from blended wheats.*

Sample No.	Commercial grade.	Bleached.	Bran particles.	Hairs.	Total.
	"Per cent clear."				
17179-L-ZZ	10	No	115	61	176
17116-L-E	15	No	127	65	192
17123-L-GG	15	No	250	73	323
17125-L-GG	15	No	297	40	337
17171-L-C	20	No	209	96	305
11093-K	27½	No	76	45	121
11094-K	27½	Lightly	55	49	104
11095-K	27½	Heavily	61	47	108
17182-L-H	30	No	166	142	308
17173-L-Y	40	No	112	98	210
17172-L-BB	50	Yes	88	44	132
17159-L-W	25	No	111	67	178

The bran particle count varied from 55 to 297, with an average count of 139, and the hair count varied from 40 to 142, with an average of 69. The total offal count varied from 104 to 337, with an average of 207.

MILL STREAMS EMPLOYED IN THE MANUFACTURE OF CERTAIN CLEAR FLOURS.

Tables 31 and 32 record the results obtained on certain mill streams which were employed in making up clear flours. As in the case of the commercial grades already considered, these figures are merely submitted to demonstrate the quality of the stocks that might be used in such a flour from the standpoint of offal material.

TABLE 31.—*Results of examination of mill streams employed in the manufacture of a clear flour (sample No. 17143-L-BB) milled from hard wheat.*

Stock.	Bran particles.	Hairs.	Total.
First and third breaks	310	59	369
Second break	324	42	366
Third break	628	107	735
Fourth break	810	213	1,023
First tailings	120	5	125
Second tailings	120	4	124
Third tailings	38	1	39
Fourth tailings	567	72	639
First germ flour	430	38	468
Second germ flour	560	33	593
First dustings flour	184	28	212
Third dustings flour	110	15	125
Dust collector material	575	99	674
25 per cent clear flour[1]	316	71	387

[1] Composited from the mill streams listed above it.

TABLE 32.—*Results of examination of mill streams employed in the manufacture of a clear flour (sample No. 11079–K–JJ) milled from hard wheat.*

Stock.	Bran particles.	Hairs.	Total.
First break	196	165	361
Third break (head)	120	121	241
Third break (tail)	100	103	203
Fifth middlings	28	24	52
Sixth middlings (head)	46	45	91
Sixth middlings (tail)	55	26	81
Seventh middlings (head)	56	27	83
First sizings	87	31	118
First tailings (head)	151	58	209
First tailings (tail)	87	32	119
22 per cent clear flour[1]	82	68	150

[1] Composited from the mill streams listed above it.

GENERAL CONCLUSIONS ON CLEAR FLOURS.

1. The commercial grades of so-called clear flours ranged from 5½ to 52 per cent.

2. The average total offal count obtained on all commercial clear flours examined was 273. This amount was decidedly in excess of the amount obtained on the commercial grades already considered.

3. As in the case of the other grades, clear flours showed a wide variation in the total offal count obtained on products from different mills.

LOW-GRADE FLOURS.

The low-grade flour is supposed to be made from low-grade mill stocks, as might be inferred from the designation applied to this class of products. As already stated, the better stocks, for the most part, are diverted into the higher grades. The streams entering into the composition of the low-grade flours are usually more or less specky, due to the presence of offal material. For this reason it is quite impossible to obtain an accurate count on such a flour. In fact, a casual microscopical examination is usually all that is necessary to determine the quality of the flour.

LOW-GRADE FLOURS MILLED FROM HARD WHEATS.

Eleven low-grade flours milled from hard wheats were examined, with the results shown in Table 33. The commercial grades ranged from 2 to 10 per cent, some of the samples being bleached and others unbleached.

TABLE 33.—*Results of examination of low-grade flours milled from hard wheats.*

Sample No.	Commercial grade.	Bleached.	Bran particles.	Hairs.	Total.
	"Per cent low-grade."				
11066–K	2	(?)	243	91	334
15118–K	2½	No	310	129	439
15119–K	2½	Lightly	340	131	471
15120–K	2½	Yes	310	112	422
15156–K–D	3	No	252	155	407
15148–K–X	2–5	No	175	88	263
11080–K–HH	5	No	353	301	654
11080–K–II	5	Yes	274	335	609
11029–K–D	8	(?)	269	264	533
11072–K–OO	6	(?)	169	163	332
11080–K–OO	10	Yes	317	238	555

The bran particle count varied from 169 to 353, with an average of 273. The hair count ranged from 88 to 335, with an average of 182. The total offal count varied from 263 to 654, with an average of 456.

LOW-GRADE FLOURS MILLED FROM SOFT WHEATS.

The eight samples of low-grade flour milled from soft wheats ranged from 2 to 10 per cent, with bleaching being practiced in some instances and not in others. Table 34 gives the results of this examination.

TABLE 34.—*Results of examination of low-grade flours milled from soft wheats.*

Sample No.	Commercial grade.	Bleached.	Bran particles.	Hairs.	Total.
	"Per cent low-grade."				
17136-L-Y	(?)	(?)	202	27	229
17185-L-G	(?)	No	143	257	400
17176-L-X	2	No	309	145	454
17188-L-W	3	No	238	261	499
15123-K-Z	4½	Yes	402	219	621
15126-K-CCC	4½	No	390	139	529
17178-L-BBS	6	No	307	124	431
17165-L-Y	10	Yes	331	80	411

The bran particle count varied from 143 to 402, with an average of 302. The hair count ranged from 27 to 261, with an average of 140. The total offal count varied from 229 to 621, with an average of 446.

LOW-GRADE FLOURS MILLED FROM BLENDED WHEATS.

Eight samples of flour stated to have been milled from blended wheats ranged in commercial grades from 1½ to 10 per cent, only one sample of the number being represented as having been bleached. The results of the examination are shown in Table 35.

TABLE 35.—*Results of examination of low-grade flours milled from blended wheats.*

Sample No.	Commercial grade.	Bleached.	Bran particles.	Hairs.	Total.
	"Per cent low-grade."				
17123-L-EE	(?)	No	394	59	453
17128-L-T	(?)	No	100	61	161
17117-L-Y	1½	No	211	76	287
17115-L-F	3½	(?)	357	141	498
17120-L-J	4	No	397	183	580
17171-L-D	5	No	237	94	331
17172-L-AA	10	Yes	281	131	412
17179-L-AAA	10	No	262	132	394

The bran particle count had limitations of from 100 to 397, with an average of 279. The hair count varied from 59 to 183, with an average of 109. The total offal count ranged from 161 to 580, with an average count of 389.

GENERAL CONCLUSIONS ON LOW-GRADE FLOURS.

1. The commercial grades of so-called low-grade flours ranged from 2 to 10 per cent.

2. The average total offal count obtained on all commercial low-grade flours examined was 433. This indicated that not as much attention was given to the purification of the stocks passing into such flours as was done in the case of the stocks composing the grades already considered.

3. The data obtained on the low-grade flours milled from the different wheats are summarized in Table 36.

TABLE 36.—*Limitations and average counts on bran particles and hairs for low-grade flours.*

Type.	Bran particles.		Hairs.	
	Variation.	Average.	Variation.	Average.
Hard wheat	169 to 353	273	88 to 335	182
Soft wheat	143 to 402	302	27 to 261	140
Blended wheat	100 to 397	279	59 to 183	109

EXAMINATION OF EXPERIMENTAL SERIES OF FLOUR.

In connection with the examination of commercial flours it was considered advisable to examine samples of flour whose composition was definitely known, as far as the wheat from which they were milled and their constituent streams were concerned. The information in regard to the commercial samples was definite enough in so far as the milling operator was able to judge.

The samples of flour employed in this part of the investigation were milled under the personal supervision of B. C. Winslow, food and drug inspector, Bureau of Chemistry, United States Department of Agriculture. The samples were prepared at a plant at Lyons, Kans., a portion being milled from a No. 2 Nebraska hard winter wheat, crop of 1914, containing from 25 to 35 per cent of yellow berry wheat, and another portion from a Kansas No. 2 hard winter wheat. Each type of flour was subjected to three degrees of bleaching, thus making three samples for each type. Four types of flour were made from each wheat, a 70 per cent, a 90 per cent, a 97.5 per cent, and a 27.5 per cent. In the case of the Kansas wheat a fifth type, a 2.5 per cent, was made. The component streams that passed into each type and the results of the examinations made were as follows:

THE 70 PER CENT TYPE OF EXPERIMENTAL FLOUR.

COMPOSITION.

First sizings flour.
Second sizings flour.
First middlings flour.
Second middlings flour.
Third middlings flour.
Fourth middlings flour.
Fifth middlings flour.
Fine tailings flour.
Coarse tailings flour.

TABLE 37.—*Results of examination of 70 per cent type of experimental flour.*

Wheat.	Sample number.	Degree of bleaching.	Bran particles.	Hairs.	Total.
No. 2 Nebraska, hard winter.	11084–K	None	29	13	42
	11085–K	Lightly	32	13	45
	11086–K	Heavily	31	18	49
No. 2 Kansas, hard winter.	15112–K	None	10	12	22
	15113–K	Lightly	12	9	21
	15114–K	Heavily	(1)	(1)	(1)
Average count			22	13	35

[1] Not counted; infested with weevils.

THE 90 PER CENT TYPE OF EXPERIMENTAL FLOUR.

COMPOSITION.

First sizings flour.
Second sizings flour.
First middlings flour.
Second middlings flour.
Third middlings flour.
Fourth middlings flour.
Fifth middlings flour.
Fine tailings flour.
Coarse tailings flour.
Second break flour.
Third break flour.
Fourth break flour.
Sharp section (middlings).
Cut-off flour (middlings).
Sixth middlings flour.
Seventh middlings flour.
Eighth middlings flour.

TABLE 38.—*Results of examination of 90 per cent type experimental flour.*

Wheat.	Sample number.	Degree of bleaching.	Bran particles.	Hairs.	Total.
No. 2 Nebraska, hard winter.	11087–K	None	50	26	76
	11088–K	Lightly	51	22	73
	11089–K	Heavily	50	28	78
No. 2 Kansas, hard winter.	15109–K	None	32	31	63
	15110–K	Lightly	31	28	59
	15111–K	Heavily	28	34	62
Average			40	28	68

THE 97.5 PER CENT TYPE OF EXPERIMENTAL FLOUR.

COMPOSITION.

First sizings flour.
Second sizings flour.
First middlings flour.
Second middlings flour.
Third middlings flour.
Fourth break flour.
Sharp section (middlings).
Cut-oft flour (middlings).
Sixth middlings flour.
Seventh middlings flour.
Fourth middlings flour.
Fifth middlings flour.
Fine tailings flour.
Coarse tailings flour.
Second break flour.
Third break flour.
Eighth middlings flour.
First break flour.
Fifth break flour.
Ninth middlings flour.
Flour from dust-collecting reels.

TABLE 39.—*Results of examination of 97.5 per cent type of experimental flour.*

Wheat.	Sample number.	Degree of bleaching.	Bran particles.	Hairs.	Total.
No. 2 Nebraska, hard winter.	11090–K	None	42	28	70
	11091–K	Lightly	43	29	72
	11092–K	Heavily	52	26	78
	15106–K	None	57	39	96
	15107–K	Lightly	43	29	72
	15108–K	Heavily	28	30	58
Average			44	30	74

THE 27.5 PER CENT TYPE OF EXPERIMENTAL FLOUR.

COMPOSITION.

Second break flour.
Third break flour.
Fourth break flour.
Sharp section.
Cut-off flour (middlings).
Sixth middlings flour.
Eighth middlings flour.
First break flour.
Fifth break flour.
Ninth break flour.
Flour from dust collectors.
Seventh middlings flour.

TABLE 40.—*Results of examination of 27.5 per cent type of experimental flour.*

Wheat.	Sample number.	Degree of bleaching.	Bran particles.	Hairs.	Total.
No. 2 Nebraska, hard winter.	11093-K	None	76	45	121
	11094-K	Lightly	55	49	104
	11095-K	Heavily	61	47	108
No. 2 Kansas, hard winter.	15115-K	None	56	65	121
	15116-K	Lightly	49	51	100
	15117-K	Heavily	51	40	91
Average			58	49	107

THE 2.5 PER CENT TYPE OF EXPERIMENTAL FLOUR.

COMPOSITION.

Bran duster flour.
Cut-off flour from seventh middlings.
Shorts duster flour.
Cut-off flour from ninth middlings.

TABLE 41.—*Results of examination of 2.5 per cent type of experimental flour.*

Wheat.	Sample number.	Degree of bleaching.	Bran particles.	Hairs.	Total.
No. 2 Kansas, hard winter.	15118-K	None	310	129	439
	15119-K	Lightly	340	131	471
	15120-K	Heavily	310	112	422
Average			320	124	444

GENERAL CONCLUSIONS ON EXPERIMENTAL TYPES OF FLOUR.

The best grade of flour of the experimental series averages a little lower in total offal count than the best grade in the commercial set, being 57 for the commercial flours and 35 for those of the experimental set. The two intermediate grades of the commercial flours were higher in the offal count than similar grades in the experimental series, the count being 111 and 273 for the commercial flours and 71 and 107 for those of the experimental set. Both of the lower-grade flours, that from the commercial and experimental sets, respectively, compared very favorably as far as the offal count was concerned, these figures being essentially minimum ones although approximately representative of the two products.

SUMMARY.

1. Microscopical technique was devised for the enumeration of the offal material in flour of various commercial grades.

2. The data obtained on the various commercial grades of flour demonstrated that there was little uniformity in the matter of grading finished flours in different mills.

3. The experimental data submitted have shown a wide range in the offal content among flours of the same commercial grade (apparently) produced by different mills.

4. The information obtained concerning the samples examined leads to the inference that all mills do not composite finished flours in the same manner.

5. The microscopical examination of the constituent streams entering into the composition of a finished flour shows the effect of the addition of different mill stocks on the resulting offal content.

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